MAINTENANCE OF OVERHEAD ELECTRICITY DISTRIBUTION LINES

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INTRODUCTION

In general, wind, rain, snow, fungi, lighting surges branches of trees and even whole trees, and sometimes animals of various sizes apart from deterioration due to continuous operation and mechanical breakdowns can stress overhead distribution lines, electrically and/or mechanically.

In order to repair and maintenance of electricity distribution lines, it is very utmost important to meet the following objectives;

i. Uninterrupted supply of electricity to associated areas

ii. Improving the performance of distribution network

iii. Strengthening of distribution system mechanically

iv. Optimization of resources associated to distribution lines

v. Effective utilization of the assets and smooth operation

KEY COMPONENTS OF POWER DISTRIBUTION LINES

Followings are the key component i.e. materials and accessories used in power distribution;

1. Poles (Supports)
2. Earthing arrangement
3. Conductors
4. Insulators
5. Guy Assembly
6. G.I. Wire
7. GO Switches
8. 11kV Cross-arms
9. L.T. Line Spacers

POLES (SUPPORTS)

The poles or supports are classified according to the material used for it:

- Steel
- Cement
- Wood

Type	Category	Advantages	Disadvantages
Steel	Rail Poles Tubular Poles	• Light in weight • Cheaper in cost • Higher mechanical strengthen • easy handling and transportation • Wind pressure is very low because of circular shape • Easy erection by digging pits of diameter slightly greater than the pole's diameter. • Circular poles are preferred in hilly areas.	• Affected by atmospheric moisture, rains, etc. • Requires frequent painting or coating with chemicals to avoid rusting.
Cement	R.C.C. P.C.C.	• Longer life, remain unaffected by rain, sunlight, etc. • R.C.C. (Reinforced Cement Concrete) poles are made by reinforcing (i.e. embedding) steel rods into concrete slabs of poles. • P.S.C. (Pre-stressed Cement Concrete) poles are made with high tensile steel wire inserted into concrete and these wires are stretched to a certain level. • Galvanised wire is used as earth wire inside the poles.	• Heavy in weight due to the presence of concrete and steel • More efforts are required in handling and transportations of these poles.
Wood	Wooden Beams	• Light in weight • Cheap in comparison to all other types of poles • Commonly used for either for temporary work or in hilly areas	• Easily affected and spoiled by atmosphere, rain water, white ants, soil moisture, etc. • Requires coating with special chemical such as Creosote for longer life.

The selection of poles for erection of lines depends on a number of factors such as pole strength, type and size of conductor, maximum wind pressure, maximum line tension, snowfall, presence of fruit farms, guarding, different crossings like river, road, railway, telephone lines etc.

As per the CEA (Central Electricity Authority) Regulations 2010, Relating to Safety and Electric Supply, Clause 57(2), the poles / supports should have the following minimum factor of safety as given in below table;

S. No.	Types of Poles / Supports	Safety Factor
1	Metal Supports	1.5
2	Mechanically processed concrete supports	2.0
3	Hand moulded concrete supports	2.5
4	Wooden supports	3.0

EARTHING ARRANGEMENT

Earthing shall generally be carried out in accordance with the requirements of CEA regulations for measures relating to safety and electricity supply, dated 20th September 2010 and the relevant regulations of the Electricity Supply Authority concerned and as the following:

1. All metal supports, fittings etc. shall be permanently and efficiently earthed. Either a continuous wire may be run with earthing arrangements at 4 points in 1.609 km or each independent structure should be efficiently earthed.
2. Similarly at consumer's premises a suitable earthing point would be provided. Consumer has to make arrangement for independent earthing.
3. Sub-stations structures etc. should be provided with two independent earthing points. This should be interconnected or matting in the sub- station area could be laid-down for connecting to the earth points.
4. For RCC/PCC poles the metal cross-arms and insulator pins shall be bonded and earthed at every pole for HT lines and at every 5th pole for LT lines.
5. All special structures on which switches, transformers, fuses, etc., are mounted should be earthed.
6. The supports on either side of the road, railway or river crossing should be earthed.
7. All supports (metal, RCC/PCC) of both HT and LT lines passing through inhabited areas, road crossings and along such other places, where earthing of all poles is considered desirable from safety considerations should be earthed.

In special locations, railway and telegraph line crossings, special structures, etc., pipe/rod earthing should be done. At other locations the coil earthing may be adopted. The coil earthing consist of 10m length of 8 SWG G.I. wire compressed into a coil 450 mm length and 50 mm diameter and buried 1500 mm deep.

CONDUCTORS

In overhead distribution lines, aluminium conductors of different types and sizes are used for drawing overhead lines, whether they are LT or HT lines. These include:

a) **AAC (All Aluminium Conductors):** This type of conductor is made up of one or more strands of hard drawn 1350 aluminium alloy. The AAC conductors are used in low and high voltage overhead lines. AAC is used extensively in urban areas where spans are usually short but high conductivity is required.

b) **ACSR (Aluminium Conductor Steel Reinforced):** It is a type of high-capacity, high-strength stranded conductor typically used in overhead power lines. The outer strands are high-purity aluminium, chosen for its excellent conductivity, low weight and low cost. The centre strand is of steel for additional strength to help support the weight of the conductor.

c) **Reinforced Conductors AAAC (All Aluminium Alloy Conductors):** These

conductors are made out of high strength Aluminium- Magnesium-Silicon Alloy. These conductors are designed to get better strength to weight ratio and offer improved electrical properties, excellent sag-tension characteristics and superior corrosion resistance when compared with ACSR.

Specifications of different types of conductors (with their code name) are mentioned below;

Code Name	Gnat	Ant	Squirrel	Weasel	Rabbit	Racoon	Dog
Nominal Aluminium Area (mm2)	25	50	20	30	50	80	100
Equivalent nominal copper area (mm2)	16	30	13	20	30	48	65
Stranding & wire diameter in mm of Aluminium (mm)	7/2.21	7/3.10	6/2.211	6/2.59	6/3.35	6/4.09	6/4.72
Stranding & wire diameter in mm of steel (mm)	-	-	1/2.11	1/2.59	1/3.35	1/4.09	1/4.72
Breaking load (kg)	485	852	771	1136	1850	2746	3299
Weight of Conductor (kg./km)	73	144	85	128	214	318	394
Calculated Resistance at 20°C in ohms/ km	1.07	0.54	1.39	0.93	0.5524	0.37	0.28
Current carrying capacity at 40°C above 30°C ambient temp.	85	135	75	102	150	202	250

The Gnat and Ant conductors (mentioned in S. No. 1 and 2) are generally used for LT Lines. The other types of conductors (mentioned from S. No. 3 to 7 are all ACSR Conductors and are commonly used on 11kv lines, except Dog conductors.

As per CEA Regulations 2010 relating to Safety and Electric Supply, Clause 7, the minimum factor of safety for conductors have to be based on their ultimate tensile strength.

INSULATORS

Insulators are used to isolate the poles (supports) from live (current carrying current) conductor to avoid any kind of shock or electric hazard. Insulators possess a high resistance to pass current through them as their atoms have tightly bound electrons that do not move throughout the material. Based on the design and use; following type of insulators are commonly used;

1. Pin Type Insulators
2. Shackle Type Insulators
3. Disc Type Insulators
4. Guy Strain Insulators

a) **Pin Type Insulators**: The pin type insulator is mounted on a pin on the cross-arm on the pole. There is a groove on the upper end of the insulator. The conductor passes through this groove and is tied to the insulator with annealed wire of the same material as the conductor.

b) **Shackle Type Insulators**: The shackle insulators are used in low voltage distribution lines (LT

lines). These insulators can be mounted either in vertical or horizontal positions.

c) **Disc Type Insulators**: In higher voltage, such as beyond 33kV, it becomes uneconomical to use pin insulator as the size and weight of the insulator becomes more. Handling and replacing bigger sized single unit insulator is a difficult task. Suspension insulator was developed to overcome these difficulties. In suspension insulator, the number of insulators are connected in a series to form a string and the line conductor is carried by the bottom most insulator. Each insulator of a suspension string is called disc insulator because of its disc-like shape.

d) **Guy Strain Insulators**: These are only used for guy/stay wires. These are designed to work in mechanical tension or strain, as they are capable to withstand the pull of a suspended electrical wire or cable.

GUY ASSEMBLY

Guy assembly is needed for dead-end and angular locations to counter balance the load on the supports due to pulling of the conductors, so that supports remain straight in vertical position without bending in any direction.

G.I. WIRE

G.I. wires are used for protective guarding at the crossing of lines with roads, railway tracks, telecommunication lines, etc. These have to be of 3.15, 4 and 5 mm sizes. The wires shall be galvanised with “heavy coating”.

GO SWITCHES

Gang operated switches or GO switches, as they are commonly called, are switching devices used in overhead power lines. They are called Gang Operated as they are operated in a Gang, all three switches together, using a single mechanism. The gang operated switches are also called Air Break Switches because air is used as the breaking medium. These are normally installed at the pole mounted distribution substation to isolate the transformer from HT line, so that the HT fuse replacement could be carried out for the restoration of supply. The GO switches are used in electrical lines with voltage of 5 kV. They can be mounted vertically or horizontally, and can be motorised and operated from a remote location.

CROSS ARMS

The following types of cross-arms are used for 11kV Lines:

a) V Cross Arms - These are widely used and have the capacity to bear heavy electrical fluctuations and voltages.
b) Double-channel Cross Arm - These are used for tension or cut point locations where D.Ps. installed.
c) L.T. Cross Arms - These have been standardised with strong structure for horizontal as well as vertical formation of conductor.

L.T. LINE SPACERS

Clashing of L.T. conductors in the mid-span very often takes place due to sag, wind and longer spans. This results in faults and interruptions. In order to overcome this problem spacers are provided. As per REC Construction Standards two types of spacers are generally used:

- Spiral - made from high quality PVC.
- Composite - made from poly-propylene in a single mould (except the clamping pieces).

REPAIR AND MAINTENANCE OF POWER DISTRIBUTION LINES

Various measures are required to be implemented to maintain and/or improve the performance of overhead distribution lines and infrastructures. Poles, conductor, and line hardware all have long life, often exceeding 50 years, but many utilities

have aging infrastructure. The deterioration and replacement of equipment must be monitored and managed to continue providing safe, reliable service. Major storms increase stresses on overhead infrastructure, and damage to the overhead distribution system can overwhelm a utility's normal response and repair, leading to customer interruptions lasting days. Hardening of overhead infrastructure or resiliency improvements to reduce damage and reduce times to repair can reduce customer impacts.

PREVENTIVE & ROUTINE MAINTENANCE

Preventive & Routine Maintenance is done primarily twice a year, once before monsoon and the next is done after monsoon to see if any breakdown has occurred in the line. Such maintenance of line improves its life drastically.

Few of the preventive measures and cheeks performed during maintenance are;

- Line patrolling,
- Maintaining adequate ground clearance,
- Replacement of insulators,
- Restringing of lines,
- Replacement of burnt jumpers,
- Replacement of damaged conductor,
- Replacement of damaged pole, etc.

BREAKDOWN MAINTENANCE

When an overhead line trips on a sustained fault, it should be inspected to find out the nature of fault such as loose sag, snapping of conductor, tree branches touching the lines, conductor falling on cross arms. An improvement with a view to avoid re-occurrence of such faults in future should be arranged and carried out soon. Complaints regarding no current/failure of power supply, voltage fluctuation, and load shedding and scheduled outages shall be addressed by the senior lineman as per the provisions of the regulations. Problems related to current such as no current or failure of power supply in premises could occur due to various reasons such as:

- Fuse blown out/tripping of MCB
- Burnt meter
- Broken service line
- Service line snapped from pole
- Fault in distribution mains
- Distribution transformer failure
- Fault in HT system
- Problem in grid (33 kV or 66 kV) substation
- Planned/scheduled/emergency maintenance work
- Load shedding
- Street light complaint Pre-monsoon Inspection

INSPECTION CHECKLIST FOR OVERHEAD POWER DISTRIBUTION LINES MAINTENANCE

Overhead powerlines maintenance is required to minimise interruptions and improve the efficiency of power supply. The overhead lines should be inspected periodically to detect any fault which may lead to break down of electric supply. When an overhead line trips, it should be inspected to find out the nature of fault. Low Tension (LT) Line Maintenance includes:

1. Alignment of poles & Leaned poles should be rectified.
2. Replacement of damaged service wire
3. Removal of bird nests
4. Tree clearance & Tree cutting should be properly executed
5. Checking of pole fittings and street light brackets
6. Careful examination of damages to L T conductor such as black spots on conductor
7. Sagging of lines should be minimised.
8. Lines should be properly aligned by tightening with proper bolts and nuts.
9. Earthing should be checked.
10. Torn insulators/flash over insulators should be replaced.

11. Jumpers at cut points should be checked up.
12. Stay wires should be properly aligned.

Ground Patrolling: The periodic patrolling (not exceeding a month) of overhead lines at ground level, while, the line is live, is called ground patrol.

Pole Inspections: The following should be checked:

- Leaning of pole
- Sinking of Earth around the Pole
- Corrosion of Metal at Ground Level (RSJ Poles)
- Cracks in Pre Stressed Cement Concrete Poles (PSCC)

Cross Arms Inspections: The following should be checked while maintaining cross arms:

- Tilting of cross arms
- Rusting of cross arms
- Bird nest or creeper on cross arm

Bindings Inspections: The looseness and cutting of bindings should be carefully observed while patrolling.

Conductors Inspections: The following should be checked while maintaining conductors;

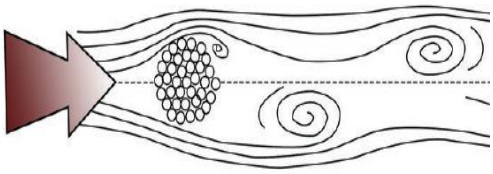
- Cut strands, burnt marks and corrosion
- Breakage/Looseness of conductors
- Spotting kites, green creepers on the conductors

Stay Wire Inspections: The following should be checked while maintaining stay wire;

- Corrosion of guy rod and stay wire
- Guy wire tightness
- Creeper on the stay wire

Conductor Inspections: Conductors checked for mechanical damages caused by followings;

a) **Aeolian vibration:** During high wind stream of air passes across a conductor, vortices (eddies) are formed on the leeward side (back side). These vortices create alternating pressures producing movement at right angles to the direction of the air flow thus aeolian vibration exerts excessive pressure on overhead power lines causing fatigue, failure of conductor strands and accessories related to the support.



b) **Galloping:** The high-amplitude, low-frequency oscillation of overhead power lines is due to wind. Sway oscillation and gallop tend to short circuit between lines thus damage is caused due to arcing. PG clamp maintains equal distance across the lines by maintaining the sag to protect from sway oscillation.
c) **Unbalance loading:** Major line failures are due to unbalance load when one phase conductor gets overheated and snapped (melted down) due to excessive current.
d) **Overloading:** When a line is loaded beyond the maximum current carrying capacity the conductor gets overheated and snapped.

Breakers Inspections: Brekaers & Switchgears require regular maintenance and following checks:

- Defect in closing of the breakers & switches
- Missing of the lock
- Damage of earth wire
- Dust accumulation on the insulators
- Blades /contacts burnings

Cable Boxes & End Terminations Inspections:

- Proper supporting of cable and cable boxes
- Damage to insulator and compound leakage from the box
- Intactness of terminal connections with overhead lines and earthing

Insulator Discs Inspections:

Due to moisture and dust particles on the surface of insulator the resistance is reduced which leads to flash over and failure of insulators due to following causes;

1. Due to difference in temperatures and hot and cold season, there is extra stress on both conductor and insulators of entire overhead network.
2. During rainy season dust over the insulator becomes conductive and forms fine hair crack which further develops to fretting due to load and lightening.
3. Excessive tightening of PG clamps causes extra strain to disc insulator, pin insulator and conductor through-out up to end points and causes tensile breaks of conductor and abrasion, fatigue on pin insulators.
4. Though lightning arresters (LA) are the most effective means of protecting electrical lines against lightning and switching, failure of LA directly impacts the insulators damage due to spark.
5. Line conductors are electrically insulated from each other as well as from the pole 'insulators'. The insulator and its binding should be mechanically strong enough to withstand the resultant force due to combined effect of wind pressure and weight of the conductor in the span.

Measuring Equipment Testing & Inspections: Proper calibration and working of equipment should be double checked before using them for testing and repair activity. In case tools used in testing are not properly working and calibrated, then it will not lead to proper adjustment of equipment which in turn would result in malfunction of the total connected system. All the equipment which are meant for testing and repair activities should be kept separately from other equipment, and should be tested for their accuracy and workability according to defined standards.

REFERENCES

1. Electric Power Distribution, T. A. Short
2. Certificate of Competency in Power Distribution, IGNOU Publication
3. Electricity Regulations, Central Electricity Authority, Ministry of Power, G.o.I.
4. Repair & Maintenance of Power Line, NCERT Publication
5. Electric Power Research Institute, "Transmission Line Reference Book, Wind Induced Conductor Motion"
6. "Preformed Line Products reference report, "Aeolian Vibration Basics", 2006
7. P.W. Dulhunty, A. Lamprecht and J. Roughens, "The Fatigue Life of Overhead Line Conductors",
8. IEEE Transactions on Dielectrics and Electrical Insulation, B Venkatesalu, M. Joy Thomas
9. Live-line maintenance of AC overhead lines equipped with non-ceramic insulators (NCI) M. de Nigris; I. Gutman; A. Pigini
10. Visual live-line condition monitoring of composite insulators Chithambaram A. Veerappan; Peter R. Green; Simon M. Rowland
11. Evaluation of field-ageing effects on insulating materials of composite suspension insulators N. C. Mavrikakis; P. N. Mikropoulos; K. Siderakis